

Appendix 5

Supplementary Material for Chapter 5

Part E 40CFR, Part 53, Subpart E

The accuracy of flow rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and at least one flow rate within ± 3 percent of 16.7 L/min within 7 days prior to use for this test. Where an instrument's measurements are to be recorded with an analog recording device, the accuracy of the entire instrument-recorder system shall be calibrated or verified.

(e) *Test setup.* (1) The candidate test sampler shall have its inlet and impactor or impactors removed. The lower end of the down tube shall be reconnected to the filter holder, using an extension of the downtube, if necessary. If the candidate sampler has a separate impactor for each channel, then for this test, the filter holder assemblies must be connected to the physical location on the sampler where the impactors would normally connect.

(2) The test particle delivery system shall be connected to the sampler downtube so that the test aerosol is introduced at the top of the downtube.

(f) *Test procedure.* (1) All surfaces of the added or modified component or components which come in contact with the aerosol flow

shall be thoroughly washed with 0.01 N NaOH and then dried.

(2) Generate aerosol. (i) Generate aerosol composed of oleic acid with a uranine fluorometric tag of $3 \pm 0.25 \mu\text{m}$ aerodynamic diameter using a vibrating orifice aerosol generator according to conventions specified in § 53.61(g).

(ii) Check for the presence of satellites and adjust the generator to minimize their production.

(iii) Calculate the aerodynamic particle size using the operating parameters of the vibrating orifice aerosol generator. The calculated aerodynamic diameter must be $3 \pm 0.25 \mu\text{m}$ aerodynamic diameter.

(3) Verify the particle size according to procedures specified in § 53.62(d)(4)(i).

(4) Collect particles on filters for a time period such that the relative error of the resulting measured fluorometric concentration for the active filter is less than 5 percent.

(5) Determine the quantity of material collected on the active filter using a calibrated fluorometer. Record the mass of fluorometric material for the active filter as $M_{\text{active}(i)}$ where i = the active channel number.

(6) Determine the quantity of material collected on each no-flow filter using a calibrated fluorometer. Record the mass of fluorometric material on each no-flow filter as $M_{\text{no-flow}}$.

(7) Using 0.01 N NaOH, wash the surfaces of the added component or components which contact the aerosol flow. Determine the quantity of material collected using a calibrated fluorometer. Record the mass of fluorometric material collected in the wash as M_{wash} .

(8) Calculate the aerosol transport as:

Equation 29

$$T_{(i)} = \frac{M_{\text{active}}}{M_{\text{active}} + M_{\text{wash}} + \sum M_{\text{no-flow}}} \times 100\%$$

where:

i = the active channel number.

(9) Repeat paragraphs (f)(1) through (8) of this section for each channel, making each channel in turn the exclusive active channel.

(g) *Test results.* The candidate Class I sampler passes the aerosol transport test if $T_{(i)}$ is at least 97 percent for each channel.

Tables to Subpart E of Part 53

Table E-1.—Summary of Test Requirements for Reference and Class I Equivalent Methods for PM_{2.5}

Subpart E Procedure	Performance Test	Performance Specification	Test Conditions	Part 50, Appendix L Reference
§ 53.52 Sampler leak check test	Sampler leak check facility	External leakage: 80 mL/min, max Internal leakage: 80 mL/min, max	Controlled leak flow rate of 80 mL/min	Sec. 7.4.6
§ 53.53 Base flow rate test	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Cut-off	1. $16.67 \pm 5\%$, L/min 2. 2%, max 3. 2%, max 4. 0.3%, max 5. Flow rate cut-off if flow rate deviates more than 10% from design flow rate for $>60 \pm 30$ seconds	(a) 6-hour normal operational test plus flow rate cut-off test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) Variable flow restriction used for cut-off test	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.4 Sec. 7.4.5
§ 53.54 Power interruption test	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Occurrence time of power interruptions 6. Elapsed sample time 7. Sample volume	1. $16.67 \pm 5\%$, L/min 2. 2%, max 3. 2%, max 4. 0.3%, max 5. ± 2 min if >60 seconds 6. ± 20 seconds 7. $\pm 2\%$, max	(a) 6-hour normal operational test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) 6 power interruptions of various durations	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.5 Sec. 7.4.12 Sec. 7.4.13 Sec. 7.4.15.4 Sec. 7.4.15.5
§ 53.55 Temperature and line voltage effect test	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Temperature meas. accuracy 6. Proper operation	1. $16.67 \pm 5\%$, L/min 2. 2 %, max 3. 2 %, max 4. 0.3 %, max 5. 2 °C	(a) 6-hour normal operational test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) Ambient temperature at -20 and +40 °C (e) Line voltage: 105 Vac to 125 Vac	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.5 Sec. 7.4.8 Sec. 7.4.15.1

Table E-1.—Summary of Test Requirements for Reference and Class I Equivalent Methods for PM_{2.5}—Continued

Subpart E Procedure	Performance Test	Performance Specification	Test Conditions	Part 50, Appendix L Reference
§ 53.56 Barometric pressure effect test	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Pressure meas. accuracy 6. Proper operation	1. $16.67 \pm 5\%$, L/min 2. 2%, max 3. 2%, max 4. 0.3%, max 5. 10 mm Hg	(a) 6-hour normal operational test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) Barometric pressure at 600 and 800 mm Hg.	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.5 Sec. 7.4.9
§ 53.57 Filter temperature control test	1. Filter temp meas. accuracy 2. Ambient temp. meas. accuracy 3. Filter temp control accuracy, sampling and non-sampling	1. 2 °C 2. 2 °C 3. Not more than 5 °C above ambient temp. for more than 30 min	(a) 4-hour simulated solar radiation, sampling (b) 4-hour simulated solar radiation, non-sampling (c) Solar flux of 1000 W/m ²	Sec. 7.4.8 Sec. 7.4.10 Sec. 7.4.11
§ 53.58 Field precision test	1. Measurement precision 2. Storage deposition test for sequential samplers	1. $P_j < 2 \mu\text{g}/\text{m}^3$ for conc. $< 40 \mu\text{g}/\text{m}^3$ (24-hr) or $< 30 \mu\text{g}/\text{m}^3$ (48-hr); or $RP_j < 5\%$ for conc. $> 40 \mu\text{g}/\text{m}^3$ (24-hr) or $> 30 \mu\text{g}/\text{m}^3$ (48-hr) 2. 50 μg , max weight gain	(a) 3 collocated samplers at 1 site for at least 10 days (b) PM _{2.5} conc. $\leq 10 \mu\text{g}/\text{m}^3$ (c) 24- or 48-hour samples (d) 5- or 10-day storage period for inactive stored filters	Sec. 5.1 Sec. 7.3.5 Sec. 8 Sec. 9 Sec. 10
The Following Requirement is Applicable to Candidate Equivalent Methods Only				
§ 53.59 Aerosol transport test	Aerosol transport	97%, min, for all channels	Determine aerosol transport through any new or modified components with respect to the reference method sampler before the filter for each channel.	

TABLE E-2.—SPECTRAL ENERGY DISTRIBUTION AND PERMITTED TOLERANCE FOR CONDUCTING RADIATIVE TESTS

Characteristic	Spectral Region			
	Ultraviolet		Visible	Infrared
Bandwidth (μm)	0.28 to 0.32	10.32 to 0.40	0.40 to 0.78	0.78 to 3.00
Irradiance (W/m ²)	5	56	450 to 550	439
Allowed Tolerance	$\pm 35\%$	$\pm 25\%$	$\pm 10\%$	$\pm 10\%$

Figures to Subpart E of Part 53

Figure E-1.—Designation Testing Checklist
DESIGNATION TESTING CHECKLIST

Auditee			Auditor signature	Date
Compliance Status: Y = Yes N = No NA = Not applicable/Not available				
Verification			Verified by Direct Observation of Process or of Documented Evidence: Performance, Design or Application Spec. Corresponding to Sections of 40 CFR Part 53 or 40 CFR Part 50, Appendix L	Verification Comments (Includes documentation of who, what, where, when, why) (Doc. #, Rev. #, Rev. Date)
Y	N	NA		
			Performance Specification Tests	
			Sample flow rate coefficient of variation (§ 53.53) (L 7.4.3)	
			Filter temperature control (sampling) (§ 53.57) (L 7.4.10)	
			Elapsed sample time accuracy (§ 53.54) (L 7.4.13)	
			Filter temperature control (post sampling) (§ 53.57) (L 7.4.10)	
			Application Specification Tests	
			Field Precision (§ 53.58) (L 5.1)	
			Meets all Appendix L requirements (part 53, subpart A, § 53.2(a)(3)) (part 53, subpart E, § 53.51(a),(d))	
			Filter Weighing (L-8)	
			Field Sampling Procedure (§ 53.30, .31, .34)	
			Design Specification Tests	
			Filter (L-6)	
			Range of Operational Conditions (L-7.4.7)	
The Following Requirements Apply Only to Class I Candidate Equivalent Methods				
			Aerosol Transport (§ 53.59)	

Figure E-2—Product Manufacturing Checklist
PRODUCT MANUFACTURING CHECKLIST

Auditee			Auditor signature	Date
Compliance Status: Y = Yes N = No NA = Not applicable/Not available				
Verification			Verified by Direct Observation of Process or of Documented Evidence: Performance, Design or Application Spec. Corresponding to Sections of 40 CFR Part 53 or 40 CFR Part 50, Appendix L	Verification Comments (Includes documentation of who, what, where, when, why) (Doc. #, Rev. #, Rev. Date)
Y	N	NA		
			Performance Specification Tests	
			Assembled operational performance (Burn-in test) (§ 53.53)	
			Sample flow rate (§ 53.53) (L 7.4.1, L 7.4.2)	
			Sample flow rate regulation (§ 53.53) (L 7.4.3)	
			Flow rate and average flow rate measurement accuracy (§ 53.53) (L 7.4.5)	
			Ambient air temperature measurement accuracy (§ 53.55) (L 7.4.8)	
			Ambient barometric pressure measurement accuracy (§ 53.56) (L 7.4.9)	
			Sample flow rate cut-off (§ 53.53) (L 7.4.4)	
			Sampler leak check facility (§ 53.52) (L 7.4.6)	
			Application Specification Tests	
			Flow rate calibration transfer standard (L-9.2)	
			Operational /Instructional manual (L-7.4.18)	
			Design Specification Tests	
			Impactor (jet width) (§ 53.51(d)(1)) (L-7.3.4.1)	
			Surface finish (§ 53.51(d)(2)) (L-7.3.7)	

Appendix A to Subpart E of Part 53--References

(1) Quality systems--Model for quality assurance in design, development, production, installation and servicing, ISO 9001. July 1994. Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

(2) American National Standard--Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs. ANSI/ASQC E4-1994. January 1995. Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

(3) Copies of section 2.12 of the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Specific Methods, EPA/600/R-94/038b, are available from Department E (MD-77B), U.S. EPA, Research Triangle Park, NC 27711.

(4) Military standard specification (mil. spec.) 8625F, Type II, Class 1 as listed in Department of Defense Index of Specifications and Standards (DODISS), available from DODSSP-Customer Service, Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 1911-5094.

(5) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements. Revised March, 1995. EPA-600/R-94-038d. Available from U.S. EPA, ORD Publications Office, Center for Environmental Research Information (CERI), 26 West Martin Luther King Drive, Cincinnati, Ohio 45268-1072 (513-569-7562).

(6) Military standard specification (mil. spec.) 810-E as listed in Department of Defense Index of Specifications and Standards (DODISS), available from DODSSP-Customer Service, Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 1911-5094.

e. Subpart F is added to read as follows:

Subpart F--Procedures for Testing Performance Characteristics of Class II Equivalent Methods for PM_{2.5}

Sec.

53.60 General provisions.

53.61 Test conditions for PM_{2.5} reference method equivalency.

53.62 Test procedure: Full wind tunnel test.

53.63 Test procedure: Wind tunnel inlet aspiration test.

53.64 Test procedure: Static fractionator test.

53.65 Test procedure: Loading test.

53.66 Test procedure: Volatility test.

Tables to Subpart F of Part 53

Table F-1--Performance Specifications for PM_{2.5} Class II Equivalent Samplers

Table F-2--Particle Sizes and Wind Speeds for Full Wind Tunnel Test, Wind Tunnel Inlet Aspiration Test, and Static Chamber Test

Table F-3--Critical Parameters of Idealized Ambient Particle Size Distributions

Table F-4--Estimated Mass Concentration Measurement of PM_{2.5} for Idealized Coarse Aerosol Size Distribution

Table F-5--Estimated Mass Concentration Measurement of PM_{2.5} for Idealized "Typical" Coarse Aerosol Size Distribution

Table F-6 Estimated Mass Concentration Measurement of PM_{2.5} for Idealized Fine Aerosol Size Distribution

Figures to Subpart F of Part 53

Figure F-1--Designation Testing Checklist

Appendix A to Subpart F of Part 53--References

Subpart F--Procedures for Testing Performance Characteristics of Class II Equivalent Methods for PM_{2.5}

§ 53.60 General provisions.

(a) This subpart sets forth the specific requirements that a PM_{2.5} sampler associated with a candidate Class II equivalent method must meet to be designated as an equivalent method for PM_{2.5}. This subpart also sets forth the explicit test procedures that must be carried out and the test results, evidence, documentation, and other materials that must be provided to EPA to demonstrate that a sampler meets all specified requirements for designation as an equivalent method.

(b) A candidate method described in an application for a reference or equivalent method application submitted under § 53.4 shall be determined by the EPA to be a Class II candidate equivalent method on the basis of the definition of a Class II equivalent method given in § 53.1.

(c) Any sampler associated with a Class II candidate equivalent method (Class II sampler) must meet all requirements for reference method samplers and Class I equivalent method samplers specified in subpart E of this part, as appropriate. In addition, a Class II sampler must meet the additional requirements as specified in paragraph (d) of this section.

(d) Except as provided in paragraphs (d)(1), (2), and (3) of this section, all Class II samplers are subject to the additional tests and performance requirements specified in § 53.62 (full wind tunnel test), § 53.65 (loading test), and § 53.66 (volatility test). Alternative tests and performance requirements, as described in paragraphs (d)(1), (2), and (3) of this section, are optionally available for certain Class II samplers which meet the requirements for reference method or Class I samplers given in 40 CFR part 50, Appendix L, and in subpart E of this part, except for specific deviations of the inlet, fractionator, or filter.

(1) *Inlet deviation.* A sampler which has been determined to be a Class II sampler solely because the design or construction of its inlet deviates from the design or construction of the inlet specified in 40 CFR part 50, Appendix L, for reference method samplers shall not be subject to the requirements of § 53.62 (full wind tunnel test), provided that it meets all requirements of § 53.63 (wind tunnel inlet aspiration test), § 53.65 (loading test), and § 53.66 (volatility test).

(2) *Fractionator deviation.* A sampler which has been determined to be a Class II sampler solely because the design or construction of its particle size fractionator deviates from the design or construction of

the particle size fractionator specified in 40 CFR part 50, Appendix L for reference method samplers shall not be subject to the requirements of § 53.62 (full wind tunnel test), provided that it meets all requirements of § 53.64 (static fractionator test), § 53.65 (loading test), and § 53.66 (volatility test).

(3) *Filter size deviation.* A sampler which has been determined to be a Class II sampler solely because its effective filtration area deviates from that of the reference method filter specified in 40 CFR part 50, Appendix L, for reference method samplers shall not be subject to the requirements of § 53.62 (full wind tunnel test) nor § 53.65 (loading test), provided it meets all requirements of § 53.66 (volatility test).

(e) *The test specifications and acceptance criteria for each test are summarized in Table F-1 of this subpart.* The candidate sampler must demonstrate performance that meets the acceptance criteria for each applicable test to be designated as an equivalent method.

(f) *Overview of various test procedures for Class II samplers--(1) Full wind tunnel test.* This test procedure is designed to ensure that the candidate sampler's effectiveness (aspiration of an ambient aerosol and penetration of the sub 2.5-micron fraction to its sample filter) will be comparable to that of a reference method sampler. The candidate sampler is challenged at wind speeds of 2 and 24 km/hr with monodisperse aerosols of the size specified in Table F-2 of this subpart. The experimental test results are then integrated with three idealized ambient distributions (typical, fine, and coarse) to yield the expected mass concentration measurement for each. The acceptance criteria are based on the results of this numerical analysis and the particle diameter for which the sampler effectiveness is 50 percent.

(2) *Wind tunnel inlet aspiration test.* The wind tunnel inlet aspiration test directly compares the inlet of the candidate sampler to the inlet of a reference method sampler with the single-sized, liquid, monodisperse challenge aerosol specified in Table F-2 of this subpart at wind speeds of 2 km/hr and 24 km/hr. The acceptance criteria, presented in Table F-1 of this subpart, is based on the relative aspiration between the candidate inlet and the reference method inlet.

(3) *Static fractionator test.* The static fractionator test determines the effectiveness of the candidate sampler's 2.5-micron fractionator under static conditions for aerosols of the size specified in Table F-2 of this subpart. The numerical analysis procedures and acceptance criteria are identical to those in the full wind tunnel test.

(4) *Loading test.* The loading test is conducted to ensure that the performance of a candidate sampler is not significantly affected by the amount of particulate deposited on its interior surfaces between periodic cleanings. The candidate sampler is artificially loaded by sampling a test